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Abstract: *This paper aims to establish whether geographical proximity between the locations of multinational firms and domestic firms facilitates the occurrence of FDI spillovers. Using data for Portugal, this hypothesis is clearly confirmed. However, the impact varies according to whether the externalities considered are horizontal or vertical. In the first case, the impact is negative, which may result from the competition effect at regional level. With regard to vertical externalities, a positive impact through backward linkages is observed. These results raise important implications for the definition of economic policies aiming to attract FDI and promote regional development.*

Key-words: vertical spillovers, horizontal spillovers, multinational firms, productivity, FDI.

JEL Codes: F21, F23

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1. Introduction

Foreign direct investment (FDI) is recognised today as one of the most vital motors for the stimulation of a country's development, and of real convergence with more developed economies. In addition to the direct effects of FDI, such as capital formation, job creation, increased tax revenues and transformation of the productive and export structures of the host countries, the attempts by countries to attract FDI are also motivated by the expectation of gaining access to more advanced technology. It is worth highlighting that the latter refers not only to the technical processes of production and distribution, but extends to management and marketing techniques (Blomström and Kokko, 1998). Domestic firms can benefit from the superior technology possessed by a multinational company (MNC) through a variety of channels and, by so doing, achieve increased productivity. If these gains are not fully absorbed by the MNCs, FDI externalities (spillovers) will be generated for the domestic firms. These externalities may occur when the foreign firm and the domestic firm operate in the same sector (horizontal spillovers) and/or in different sectors vertically related (vertical spillovers).

The relevance of these types of effects for the host economy has inspired a vast body of studies seeking to investigate the existence and magnitude of these effects. The pioneering work was conducted by Caves (1974), but it was only in the 1990s that researchers increasingly turned their attention to this domain. However, the range of findings produced highly ambiguous conclusions.

Recent research on this question has shown that the phenomenon of spillovers will only occur among a sub-group of firms, with certain characteristics in common.

Therefore, the results based on the “global” effect, that is, the effect on the whole group of firms in the sample studied, could convey an incomplete view of the reality. Effectively, it seems clear today that the main way to conduct a research study into the existence of FDI spillovers for domestic firms is to focus on a detailed theoretical and empirical evaluation of the factors that determine the occurrence, the magnitude and the sign of the FDI externalities.¹

The objective of the present study is to pursue this line of research by analysing the importance of geographical proximity between domestic firms and MNCs in the occurrence of the phenomenon. The analysis simultaneously takes into consideration the horizontal and vertical effects and analyses the effect of geographical proximity using a regional concept appropriate to our purpose.

The paper is organised as follows. Section 2 presents the main channels for the transmission of FDI externalities to domestic firms. Section 3 provides a brief overview of the existing empirical evidence. Section 4 analyses the occurrence of spillovers in the case of Portugal. Finally, our concluding remarks are presented in Section 5.

2. Channels of Transmission of FDI Spillovers to Domestic Firms

FDI spillovers can occur through five main channels: demonstration/imitation; exports, labour mobility; competition and backward and forward linkages with domestic firms (Halpern and Muraközy, 2005; Crespo and Fontoura, 2007a). The former four channels are mainly related to horizontal externalities, while the last channel concerns vertical externalities.

Demonstration by MNCs / imitation by domestic firms is probably the most evident spillover channel (Das, 1987; Wang and Blomström, 1992). The introduction of a new technology may be too expensive and risky for the domestic firms, due to the uncertainty of the results that may be obtained. If that technology is successfully used by a MNCs that may encourage the domestic firm to adopt it through imitation. The relevance of this effect increases if goods produced by the two firms are similar (Barrios and Strobl, 2002).

Exports are a second possible channel for FDI spillovers. Several studies have highlighted the positive impact of a MNC on the export capacity of domestic firms (Rhee, 1990; Aitken et al., 1997; Kokko et al., 2001). Export involves costs associated with the establishment of distribution networks, transport infrastructures or knowledge of consumers' tastes in foreign markets which MNCs are more able to afford. By following the export process of foreign firms (through imitation or, in specific circumstances, through collaboration), domestic firms may reduce the entry costs into the foreign market. The gains obtained in this way may have favourable repercussions on the productive efficiency of domestic firms (Bernard e Jensen, 1999; Sgard, 2001; Girma, 2003; Greenaway et al., 2004).

A third channel is related to the possibility of domestic firms hiring workers who, having previously worked for a MNC, have knowledge and experience of the technology (Fosfuri et al., 2001; Glass and Saggi, 2002; Görg and Strobl, 2005). The influence of labour mobility on the efficiency of domestic firms is however difficult to evaluate, as it involves tracking the workers in order to investigate their impact on the productivity of other workers (Saggi, 2002). Nevertheless, it is important to stress a possible negative impact arising from this channel, as MNCs may attract the best workers from domestic firms by offering higher wages (Sinami and Meyer, 2004).

The increased competition induced by MNCs is a fourth channel of FDI spillovers (Wang and Blomström, 1992; Markusen and Venables, 1999). Competition in the domestic economy between MNCs and domestic firms is, on the one hand, an incentive for the latter to make a more efficient use of existing resources and technology or even to adopt new technologies. On the other hand, the presence of MNCs may imply significant losses in (domestic) market shares, driving operation to a less efficient scale, with a consequent increase in average costs (Harrison, 1994; Aitken and Harrison, 1999).

A final channel concerns the relationships that domestic firms establish in local markets as suppliers of MNCs (backward linkages) or customers of intermediate inputs produced by them (forward linkages), as pointed out, for instance, by Lall (1980), and formalised by Rodríguez-Clare (1996), Markusen and Venables (1999) or Lin and Saggi (2004).

Let us firstly consider the case of backward linkages. With increasing returns to scale, the presence of MNCs may benefit domestic suppliers if it increases the demand for local inputs. In their attempts to assure a certain quality pattern, MNCs may also benefit domestic suppliers in several ways: providing technical support for the improvement of the quality of goods or for the introduction of innovations (for instance, through labour training), providing support for the creation of productive infrastructures and for the acquisition of raw materials, as well as support at the organizational and management levels, among other aspects (Lall, 1980; Reganati and Sica, 2005).

As far as the channel of forward linkages is concerned, the most evident link consists in the MNCs' supply of higher quality inputs and/or at a lower price to domestic producers of end-user consumer goods (Markusen and Venables, 1999).

Nevertheless, it is not possible to exclude another likely negative impact as production quality upgrade induced by the presence of the MNCs may lead to an increase in prices which penalises domestic firms' costs (Javorcik, 2004).

From the presentation above it is evident that the expected impact of the external presence on the productivity of domestic firms is ambiguous, as opposing effects are possible. However, some authors have argued that positive vertical externalities are more probable than horizontal ones, based on the fact that the possibly negative effect associated with the competition and the labour mobility channels is more likely at the intra-sectoral level and the efficiency gains are easier to obtain in backward-forward relations, due to greater incentive to cooperation (Kugler, 2001).²

It has been suggested recently that FDI spillovers (both positive and negative) have a circumscribed geographical dimension or, at least, that they decrease with (physical) distance (Audretsch and Feldman, 1996; Audretsch, 1998; Keller, 2002; Madariaga and Poncet, 2007), as channels of technological diffusion are reinforced at the regional level (Girma and Wakelin, 2001; Girma, 2003; Torlak, 2004; Jordaan, 2005). This and the previous idea are explored in this paper.

3. Previous empirical evidence

As mentioned above, a substantial body of literature has been produced to analyse, at the empirical level, whether the presence of MNCs results in an increase of the productivity of domestic firms in host countries. Most studies that have evaluated the existence of FDI spillovers are circumscribed to intra-sectoral spillovers. Only recently research on inter-sectoral spillovers has emerged (Barrios and Strobl, 2002;

Schoors and van der Tol, 2002, Damijan et al. 2003; Yudaeva et al., 2003; Kugler, 2006). Measurement difficulties seem to be the main reason for this scarce attention. There is not however any relevant theoretical reason to confine the analysis to horizontal externalities, as mentioned in section 2.

Robust empirical evidence for FDI spillovers is nonetheless hard to find, as, for instance, the surveys by Görg and Greenaway (2004) and Crespo and Fontoura (2007a) show. In what concerns horizontal externalities, while pioneering evidence suggested a positive spillover effect, more recent studies, using econometric techniques that are more adequate, point to heterogeneity on the spillover result, with many non-significant or even negative results. The same heterogeneity is evident for vertical externalities.

Ambiguity in the sign of the spillover effect has been associated with the data used.³ As shown by Görg and Strobl (2001) and Görg and Greenaway (2004), the results for the spillover effect appear to be affected if the data used are cross-sectional or panel data. The sign obtained is frequently negative with a panel dataset, in contradiction with the results obtained with many cross-sectional studies. It is well known that the cross-sectional approach may induce significant bias in the estimation of the coefficients if there are unobserved time-invariant firm or specific effects on the relationship between the MNCs and productivity that are correlated with the explanatory variable of the model. Together with the fact that the development of domestic firms' productivity should be analysed over a long period of time and the improvement on panel data estimating techniques, this explains why most recent studies on the subject have opted for panel data models.

Some (scarce) panel data studies using disaggregation at the sectoral level (Santos, 1991; Liu, 2002; Kugler, 2001; Driffield and Love, 2006; Flôres et al., 2007)

give some support to the existence of horizontal spillovers or, in some cases, of non-significant effects, in line with sectional studies. With data disaggregated at the firm level, lack of robustness on the role of foreign presence for horizontal spillovers becomes more evident. In a large sample of panel data studies with disaggregation at the firm level, Crespo and Fontoura (2007b) observe that in 59 cases, 31 point to a non-significant impact, 16 to a positive impact and 12 to a negative effect.⁴ The same ambiguity is present in the case of vertical externalities: with regard to backward linkages, Crespo and Fontoura (2007b) find seven studies with a positive sign, one with a negative sign and seven with non-significant results, while the three studies surveyed for forward linkages display a negative sign.

Recent literature stresses that it is possible that the expected spillover effect is not observed at a more aggregate level (for all industries) but only in the case of a sub-set of firms/sectors, which display some common characteristics. Besides the already mentioned idea that spillover channels are stronger at the regional level, several other factors have been tested, such as the capacity of domestic firm to absorb the foreign technology (Kinoshita, 2001; Schoors and van der Tol, 2002; Kanturia, 2002; Keller and Yeaple, 2003; Girma, 2003; Karpaty and Lundberg, 2004; Girma and Görg, 2005; Marin and Bell, 2006; Békés et al., 2006), the size and market share of domestic firms (Aitken and Harrison, 1999; Sinani and Meyer, 2004; Merlevede and Schoors, 2006), the export capacity of domestic firms (Blomström and Sjöholm, 1999; Ponomareva, 2000; Schoors and van der Tol, 2002; Békés et al., 2006), the national origin from which the FDI emanates (Haskel et al., 2002; Banga, 2003; Tong and Hu, 2003; Karpaty and Lundberg, 2004; Wei and Liu, 2004; Takii, 2007), the degree of foreign ownership of the MNCs' affiliates (Blomström and Sjöholm, 1999; Dimelis and Louri, 2002; Javorcik, 2004; Merlevede and Schoors, 2006), the FDI

entry mode (Braconier et al., 2001; Jabbour and Mucchielli, 2004), the nature of the trade policy regime (Kokko et al., 2001), the existence of intellectual property rights and the kind of labour training implemented by the MNC (Fosfuri et al., 2001), the competition level (Wang and Blomström, 1992), the “value” of the foreign technology (Blomström et al., 2000) or the FDI motivation (Fosfuri and Motta, 1999; Driffield and Love, 2006). However, empirical evidence does not allow definite conclusions for the majority of the possible determinant factors, as it is basically inconsistent or still insufficient to produce unequivocal conclusions (Crespo and Fontoura, 2007a).

In what concerns the regional effect, it is not confirmed by Sjöholm (1999), Aitken and Harrison (1999) and Yudaeva et al. (2003) with data for Indonesia, Venezuela and Russia, respectively. However, other studies draw conclusions to the contrary. It is the case of Ponomareva (2000), with data for Russia, Girma and Wakelin (2001) and Girma (2003), with data for the United Kingdom, Wei e Liu (2004), with data for China, and Torlak (2004), considering the case of the Czech Republic and Poland. However, in the latter study, when the so-called agglomeration effect is controlled, the positive influence at the regional level only holds firm in the case of the Czech Republic.

Halpern and Muraközy (2005)’s study of the Hungarian case is the most detailed to evaluate the existence of a regional effect. They find (statistically significant) horizontal and backward spillovers for domestic-owned firms at the national space but not at the regional level.

4. Application to the Portuguese Case

Taking the Portuguese case as reference for the empirical analysis, we propose in this section to test for the existence of a regional effect in the occurrence of FDI spillovers, in relation to both the horizontal and vertical spillovers.

Most studies that investigate the possible existence of a regional effect in the occurrence of FDI spillovers have adopted, in spatial terms, the countries' administrative divisions as the criterion for the definition of the regions.⁵ This procedure, despite the fact that it simplifies the analysis, leads to greater difficulties in respect of the evaluation of the geographical proximity effect, as the regional boundary is not necessarily related with the distance effect that we aim to capture. Indeed, two firms may be in different administrative divisions but geographically close. In the present work, we define the spatial unit as the region which comprises the county in which the domestic firm is located⁶, together with all of the directly neighbouring counties.⁷ Therefore, the magnitude of the external presence is measured within the framework of these geographical units that have been specifically constructed for the purpose of this evaluation.

The analysis is based on statistical data from Dun & Bradstreet, embracing the period 1996-2000. This data base contains information on 1303 Portuguese firms for each of the years in the period studied, which enabled us to obtain a panel data comprising 6515 observations. With reference to the multinational firms operating in Portugal, the data available relates to 266 firms in 1996, 262 in 1997, 300 in 1998, 322 in 1999 and 275 in 2000.⁸

As is customary, the procedure used to test for the occurrence of FDI spillovers involves the evaluation of the magnitude of the influence of the external presence on the domestic firms' efficiency. The variable $PROD_{it}$ – labour productivity of the domestic firm i , in the year t – corresponds, similarly to several other studies in

this field, to the dependent variable used, seeking to capture the efficiency of the domestic firms.

In addition to one or more variables intended to capture the influence of the dimension of the external presence on different spatial and sectoral scales⁹, the set of explanatory variables contains various control variables (defined in Table 1) that have influence on domestic firms' efficiency.

Table 1: Definition of the control variables

Variable	Definition
SL_{it}	skilled labour – total remuneration per worker in domestic firm i , at time t .
CI_{it}	capitalistic intensity – total fixed assets of domestic firm i divided by the number of workers, at time t .
$H_{it} = \sum_{g \in J} \left(\frac{X_{gt}}{\sum_{g \in J} X_{gt}} \right)^2 \times 100$	degree of concentration – Herfindhal concentration index, where X_{gt} represents the output of firm g , at time t ; g is an index for the firms (domestic or foreign) belonging to sector J to which domestic firm i belongs.
SE_{it}	scale economies – ratio between the value of the production of firm i , at time t and the average value of the production of the y largest firms in the sector where the firm i operates, at the same time t . The value of y is obtained as the largest value found in $1/H_{it}$.

In addition, annual dummy variables to control for the productivity evolution of the Portuguese domestic firms are included in the regression ($D1997$, $D1998$, $D1999$ and $D2000$).

The existence of FDI spillovers is tested by means of a set of variables that capture the dimension (in relative terms) of the external presence. Following the option adopted by, for example, Kokko (1994, 1996), Farinha and Mata (1996),

Kinoshita (2001), Keller and Yeaple (2003), Girma (2003) or Karpaty and Lundberg (2004), we use data on employment – obtained from the *Quadros de Pessoal*, provided by the Ministry of Employment – in order to quantify the relative weight of the MNCs at sectoral level.

We consider six variables related to the dimension of the external presence.¹⁰

The variable *FPI* measures the weight of employment in the foreign firms in the total employment of the sector where the firm *i* operates, capturing the possible existence of horizontal spillovers at the national level. The occurrence of vertical spillovers at this level of analysis is tested through the variables *FP2* and *FP3*. The variable *FP2* captures the occurrence of vertical spillovers, that is, in the case in which the foreign firms supply local firms (forward linkages). *FP2* is a weighted average of the *FPI* values, the weights being given by the relative importance, for the sector where firm *i* operates, of the various sectors that supply the sector in question (excluding the sector where firm *i* operates). *FP3* is constructed by the same method, but this time with the focus on the relation in which the foreign firms are supplied by the local firms (backward linkages).

The importance of the regional effect in the occurrence of FDI spillovers is evaluated on the basis of three new variables defined at the regional level: *FP4*, *FP5* and *FP6*. Their construction follows the procedure described above with reference to *FPI*, *FP2* and *FP3* respectively, but now in the context of the regional geographical units obtained as explained earlier.

To summarise, the model used to estimate the spillover effects has the following specification:

$$PROD_{it} = \beta_1 + \sum_{j \in J} \theta_j FPj_{it} + \beta_2 SL_{it} + \beta_3 SE_{it} + \beta_4 CI_{it} + \beta_5 H_{it} + \sum_l \lambda D_{l_{it}} + \eta_i + \varepsilon_{it}$$

$$i = 1, \dots, n; t = 1996, \dots, 2000$$
(1)

where the variables FPj ($j=1, \dots, 6$), SL , SE , CI , H , DI ($l=1997, \dots, 2000$) have the previously-mentioned significance, η_i is the specific non-observed effect of the firm on productivity (constant through the time), while ε_{it} represents the random error.

The estimation of equation (1) is made with the GMM System, proposed by Blundell and Bond (2000) with robust estimation of covariance matrices. The estimation of the covariance matrix was considered robust to heteroskedasticity (among firms) and to (unknown) autocorrelation.¹¹ This method allows consistent estimations whenever the non-observed heterogeneity (constant through the time) of the firms depends on explanatory variables of the model, and whenever endogenous regressors exist as long as an adequate choice of the instruments is made.

The variables related to the dimension of the foreign presence in the same sector as the domestic firm (FPI and $FP4$) were considered to be endogenous, as were the skilled labour variable (SL). It is well known that high productivity sectors or firms may attract the location of MNCs in the same sector, yielding a positive relationship even without spillovers taking place, as emphasised by Aitken and Harrison (1999). Furthermore, it is highly plausible that workers' remuneration, the proxy for skilled labour, may also depend on productivity itself.

Table 2 presents the results obtained. In all of the estimations, the Hansen test does not raise any doubts as to the validity of the instruments, while the Arellano and Bond tests do not reject the of absence of autocorrelation.

Table 2: FDI Spillovers for Domestic Firms

Independent variables	[1]	[2]	[3]
C	1083,55 (0,65)	-860,69 (-0,50)	222,52 (0,14)
FP1	-102,93 (-1,33)	-45,59 (-1,04)	108,46 (1,30)
FP2		21,34 (0,81)	15,42 (0,61)
FP3		62,21** (2,03)	-69,65 (-1,47)
FP4			-204,80** (-2,39)
FP5			7,74 (0,21)
FP6			129,96** (2,21)
SL	1,72*** (7,98)	1,70*** (9,01)	1,65*** (9,20)
SE	30,18* (1,80)	41,46*** (2,71)	39,21*** (2,72)
CI	0,01 (1,43)	0,01 (1,60)	0,01 (1,53)
H	240,23 (1,43)	66,97 (0,56)	106,91 (0,82)
D1997	-102,19 (-0,37)	-321,32 (-0,98)	-113,31 (-0,36)
D1998	177,82 (0,47)	106,15 (0,29)	272,90 (0,67)
D1999	-373,96 (-0,70)	-509,36 (-0,99)	-337,33 (-0,63)
D2000	-730,14 (-1,05)	-1000,26 (-1,40)	-718,67 (-1,02)
Hansen Test (p-value)	10,30 (0,590)	23,32 (0,105)	26,69 (0,319)
Arellano-Bond Test for AR(1) (p-value)	-1,37 (0,172)	-1,36 (0,174)	-1,36 (0,174)
for AR(2) (p-value)	-0,61 (0,543)	-0,62 (0,538)	-0,61 (0,542)
Nr. of Observations (nr. of firms)	6515 (1303)	6515 (1303)	6515 (1303)

t-statistics in parentheses based on robust standard-errors; *, **, *** - statistically significant at the 10%, 5% and 1% levels, respectively.

Model [1] corresponds to the most frequently used specification in the analysis of the existence of FDI spillovers for domestic firms, thus enabling a direct comparison with the ample evidence already produced in this domain. In this context, only the occurrence of horizontal spillovers is tested, the entirety of the country being adopted as the spatial scale of evaluation. Therefore, in equation (1), only *FPI* is considered, the effect of spillovers being measured by θ_i . The fact that *FPI* is not

significant is, as we highlight in Section 3, consistent with the prevailing evidence, in particular that found in the body of studies that have used panel data.

Model [2] expands the evaluation of the FDI externalities so as to include, simultaneously, variables aiming to capture the horizontal and vertical spillovers, while maintaining the country as the geographical unit of analysis. In this case, equation (1) contains the variables $FP1$, $FP2$ and $FP3$, θ_1 measuring the horizontal effect while θ_2 and θ_3 measure the vertical effects. The results obtained suggest the occurrence of a positive and significant inter-sectoral effect, benefiting the domestic firms by means of backward linkages.

After having evaluated the existence of FDI spillovers with variables defined at the national space, we now turn our attention to a model that incorporates variables constructed at a regional scale. Equation (1) now contains all of the variables that capture the dimension of the external presence. Hence, in addition to the domestic effects, measured by θ_1 , θ_2 and θ_3 , the spillover effects, both horizontal (through θ_4) and vertical (through θ_5 and θ_6), are evaluated at regional level.

The evidence in relation to model [3] clearly demonstrates the importance of the regional effect in the occurrence of the phenomenon studied, in that the existence of FDI externalities is only confirmed at this geographical level of analysis. In fact, all of the variables that capture the relative dimension of the external presence at the national level ($FP1$, $FP2$ and $FP3$) are found to be non significant. With reference to the regional level, evidence exists of FDI externalities, both inter- and intra-sectoral, although with opposing signs. With regard to the horizontal spillovers, a negative impact of the presence of MNCs is detected, probably due to the negative influence of the competition channel being more accentuated at regional level. Turning to the vertical spillovers, a positive impact is found to exist in the case of local firms that

supply the MNCs (backward linkages), since *FP6* is significant. For its part, the inter-sectoral impact through forward linkages is not statistically significant.

The evidence produced by model [3] permits us to conclude that the most relevant spillover effects take place within a limited spatial scale, suggesting that it is advisable not to confine research to merely the national dimension. In fact, the latter procedure could conceal the existence of significant effects in the more restricted geographical scales.

5. Concluding Remarks

The analysis which has been conducted in this paper has allowed us to confirm the decisive importance of the geographical proximity between MNCs and domestic firms in relation to the occurrence of FDI spillovers. When a model that simultaneously incorporates regional and domestic scales of analysis is considered, it is verified that only the effects measured at regional level are found to be significant, although they differ according to whether inter- or intra-sectoral effects are studied. The existence of positive externalities only at the inter-sectoral level confirms the theoretical hypothesis that FDI spillovers would occur more easily in this context, thus emphasising the importance of evaluating these relations (together with the intra-sectoral relations) in similar studies for other countries.

Furthermore, the set of results obtained enables us to derive certain messages of relevance to economic policy. Firstly, the importance of geographical proximity as a determinant factor of FDI spillovers underlines the need to develop active regional policies that aim to attract FDI, to the extent at which, increasingly, the competition to capture it takes place not only at national level, but also among the various regions.

Thus, both the domestic and regional authorities are presented with the task of creating conditions favourable for FDI. Secondly, the evidence pointing to the existence of positive effects only in the vertical relations between domestic firms and MNCs highlights the advantage to be drawn from the conception of policies prioritising FDI that establishes more relevant inter-sectoral relations with the domestic firms. Finally, in relation to the stimulation of productivity, the negative link between domestic and foreign enterprises operating in the same sector and that are located in close geographical proximity to each other constitutes a factor that should not be overlooked.

We have approached a specific conditioning factor in the occurrence of FDI spillovers. Future research should replicate this analysis to other countries in order to check the robustness of our empirical conclusions. Naturally, much work remains to be carried out in order to expand knowledge on the impact of the MNCs' presence on the efficiency of domestic firms. In this context, a deeper analysis of other conditioning factors of FDI spillovers would be particularly valuable, with a view to determining, with greater accuracy, the concrete circumstances which facilitate or inhibit the manifestation of this phenomenon, drawing from this the appropriate consequences in terms of attracting FDI and promoting economic development.

Appendix

Let us define i , m and g as the indices for, respectively, the domestic firm, the MNC and any firm (domestic or foreign). The index s represents the sector to which the firm belongs and the index t represents time ($t = 1996, \dots, 2000$). S is the set of all sectors of the economy. In this study, sectors are considered at the two-digit level of the CAE – revision 2, with respect to the manufacturing industry (sectors 15 a 37).¹² M_s and G_s represent, respectively, the set of the MNCs belonging to sector s and the set of all firms belonging to this sector. Foreign presence is measured with employment data, represented by X . Horizontal spillovers at the domestic level are measured by:

$$FP\ 1_{st} = \frac{\sum_{m \in M_s} X_{mt}}{\sum_{g \in G_s} X_{gt}} \quad [A.1]$$

Vertical spillovers are measured by the variables $FP2$ and $FP3$. The $FP2$ variable measures vertical spillovers through forward linkages as follows:

$$FP\ 2_{st} = \sum_{\substack{j \in S \\ j \neq s}} \alpha_{sjt} \times FP\ 1_{jt} \quad [A.2]$$

with:

$$\alpha_{s,jt} = \frac{C_{s,jt}}{\sum_{\substack{l \in S \\ l \neq s}} C_{s,lt}} \quad [A.3]$$

where $C_{s,jt}$ denotes the weights of sector j in terms of acquisitions made by sector s , in each year t . These values are obtained from the input-output matrices sourced by the Instituto Nacional de Estatística (INE).

The $FP3$ variable measures vertical spillovers through backward linkages as follows:

$$FP3_{st} = \sum_{\substack{j \in S \\ j \neq s}} \eta_{s,jt} \times FPI_{jt} \quad [A.4]$$

with:

$$\eta_{s,jt} = \frac{V_{s,jt}}{\sum_{\substack{l \in S \\ l \neq s}} V_{s,lt}} \quad [A.5]$$

$V_{s,jt}$ denotes the weight of sector j in terms of the sales of sector s in year t .

Considering a spatial division of Portugal by counties, the next step of our analysis is to construct the regions used in the evaluation of the regional dimension. Considering that there are 275 counties in mainland Portugal, we build 275 regions – designated by r – made up by the county and by all the directly neighbouring counties.

Let us thus define M_{sr} as the set of the MNCs belonging to sector s located in region r and G_{sr} as the set of all firms (domestic or foreign) belonging to sector s and

located in region r . The variable that measures horizontal externalities at the regional level is:

$$FP\ 4_{rst} = \frac{\sum_{m \in Mrs} X_{mt}}{\sum_{g \in Grs} X_{gt}} \quad [A.6]$$

The variable that measures vertical externalities through forward linkages at the regional level is:

$$FP\ 5_{rst} = \sum_{\substack{j \in S \\ j \neq s}} \alpha s_{jt} \times FP\ 4_{rjt} \quad [A.7]$$

where αs_{jt} is given as in [A.3].

The variable that measures vertical externalities through backward linkages at the regional level is given by:

$$FP\ 6_{rst} = \sum_{\substack{j \in S \\ j \neq s}} \eta s_{jt} \times FP\ 4_{rjt} \quad [A.8]$$

where ηs_{jt} is given as in [A.5].

Finally, let us define:

$$FP1_{it} = FP1_{st} \quad [A.9]$$

$$FP2_{it} = FP2_{st} \quad [A.10]$$

$$FP3_{it} = FP3_{st} \quad [A.11]$$

$$FP4_{it} = FP4_{rst} \quad [A.12]$$

$$FP5_{it} = FP5_{rst} \quad [A.13]$$

$$FP6_{it} = FP6_{rst} \quad [A.14]$$

where s is the index for the sector where firm i operates and r is the index for the region where firm i is located.

Endnotes

¹ Chang et al. (2007) widen the discussion to consider the possible existence of spillovers from “modernised” domestic firms to the remaining domestic firms.

² See also Harris and Robinson (2004) or Reganati and Sica (2005).

³ For a discussion of some problems in empirical spillovers literature, see Hale and Long (2007).

⁴ Proença et al. (2006) stress that some econometric problems inherent to the traditional panel data methods may have produced a significant under-evaluation of spillover results in previous empirical studies.

⁵ The above-mentioned study of Halpern and Muraközy (2005) is an exception.

⁶ Mainland Portugal (which excludes the islands of Madeira and the Azores) is divided into 5 NUTS II, 28 NUTS III and 275 counties.

⁷ Note that the county is an administrative region much smaller than the one used in most studies on the subject.

⁸ Our analysis is only concerned with firms located in mainland Portugal, thereby excluding those located in Madeira and the Azores.

⁹ See Wei and Liu (2004) for a comparison of alternative means of measuring the external presence.

¹⁰ See the Appendix.

¹¹ The calculations were obtained with the *Stata*, using the *xtabond2* module developed by Roodman (2005).

¹² At this level of aggregation, this nomenclature is fully compatible with NACE-Eurostat.

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